Problem Solving

(5) Determine f_1 of a CLOSED-ended air column

$L = 67.5 cm$

$L = \frac{1}{4}\lambda$

$67.5 cm = \frac{1}{4}\lambda$

$\lambda = 270 cm$

$v = \lambda f$

$340 \frac{m}{s} = (2.7 m) f_1$

$f_1 = 126 Hz$

(6) Determine Length of CLOSED ended air column required to produce a fundamental frequency of 480Hz.

$v = \lambda f$

$340 m/s = \lambda (480 Hz)$

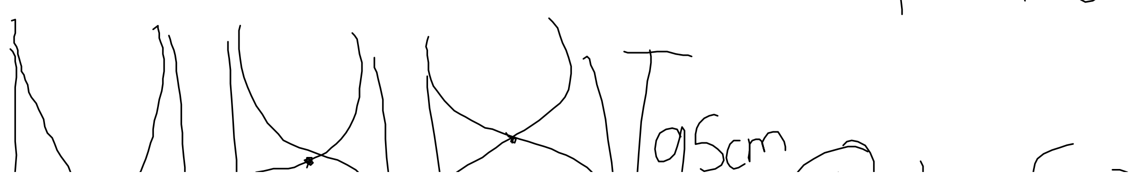
$\lambda = 0.708 m$

$\lambda = 4L$

$0.708 = 4L$

$L = 0.177 m$

(11) 3rd resonance length of closed air column = 95cm. Determine 1st + 2nd



(5th) $L = \frac{5}{4}\lambda$

$95 = \frac{5}{4}\lambda$

$\lambda = 76$

(1st) $L = \frac{1}{4}\lambda$

$= \frac{1}{4}(76)$

$L = 19cm$

(3Rd) $L = \frac{3}{4}\lambda$

$= \frac{3}{4}(76)$

$L = 57cm$

(17) 85cm guitar string

Speed of <u>vibration</u> = 332 m/s

(13) $L_2 - L_1 = 20.2$

$\lambda - \frac{1}{2}\lambda = 20.2$

$\frac{1}{2}\lambda = 20.2$

$\lambda = 40.4cm$

$\lambda = 40.4\,cm$

$v = \lambda f$

$347\,m/s = (.404\,m)\,f$

$f = 860\,Hz$

<u>Intensity</u> of a sound wave

- Amount of energy transported past a given area of the medium per unit of time
- Watts/m^2

$$\text{Intensity} = \frac{\text{Energy}}{\text{Time * Area}} \quad \text{or} \quad \text{Intensity} = \frac{\text{Power}}{\text{Area}}$$

Sound level/Decibels

- The threshold of hearing is assigned a sound level of 0 decibels (abbreviated 0 dB); this sound corresponds to an intensity of $1*10^{-12}$ W/m^2

- Scale based on powers of 10
- sound that is 10 times more intense ($1*10^{-11}$ W/m^2) is assigned a sound level of 10 dB.

- A sound that is 10*10 or 100 times more intense ($1*10^{-10}$ W/m^2) is assigned a sound level of 20 db.

- A sound that is 10*10*10 or 1000 times more intense ($1*10^{-9}$ W/m^2) is assigned a sound level of 30 db.
- A sound that is 10*10*10*10 or 10000 times more intense ($1*10^{-8}$ W/m^2) is assigned a sound level of 40 db.

Source	Intensity	Intensity Level	# of Times Greater Than TOH
Threshold of Hearing (TOH)	$1*10^{-12}$ W/m^2	0 dB	10^0
Rustling Leaves	$1*10^{-11}$ W/m^2	10 dB	10^1
Whisper	$1*10^{-10}$ W/m^2	20 dB	10^2
Normal Conversation	$1*10^{-6}$ W/m^2	60 dB	10^6
Busy Street Traffic	$1*10^{-5}$ W/m^2	70 dB	10^7
Vacuum Cleaner	$1*10^{-4}$ W/m^2	80 dB	10^8
Large Orchestra	$6.3*10^{-3}$ W/m^2	98 dB	$10^{9.8}$
Walkman at Maximum Level	$1*10^{-2}$ W/m^2	100 dB	10^{10}
Front Rows of Rock Concert	$1*10^{-1}$ W/m^2	110 dB	10^{11}
Threshold of Pain	$1*10^{1}$ W/m^2	130 dB	10^{13}
Military Jet Takeoff	$1*10^{2}$ W/m^2	140 dB	10^{14}
Instant Perforation of Eardrum	$1*10^{4}$ W/m^2	160 dB	10^{16}

octave - any two sounds whose frequencies make a 2:1 ratio are said to be separated by an **octave**

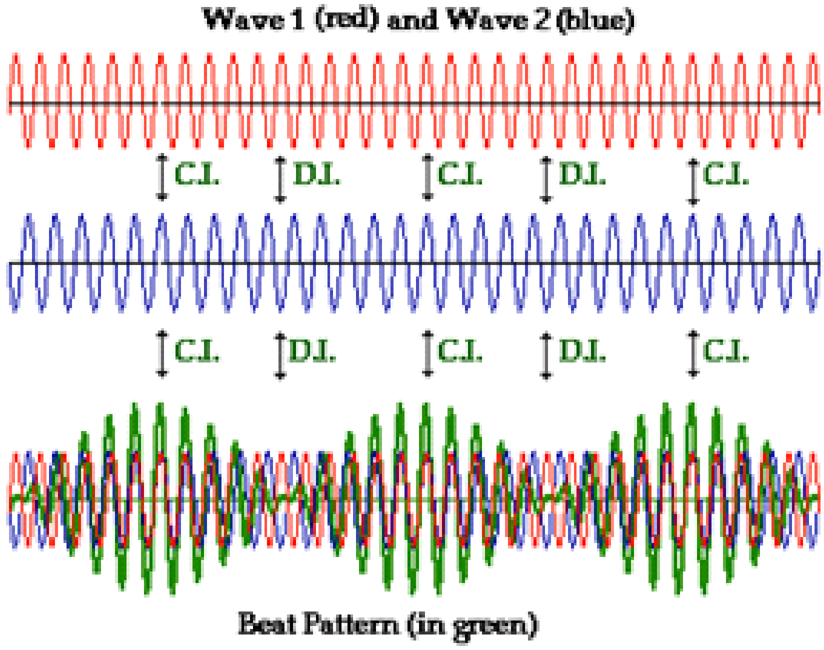
Interval	Frequency Ratio	Examples
Octave	2:1	512 Hz and 256 Hz
Third	5:4	320 Hz and 256 Hz
Fourth	4:3	342 Hz and 256 Hz
Fifth	3:2	384 Hz and 256 Hz

Example:

A musical note that is separated by an octave from middle C (256 Hz) has a frequency of: 512 Hz
128 Hz

Beats

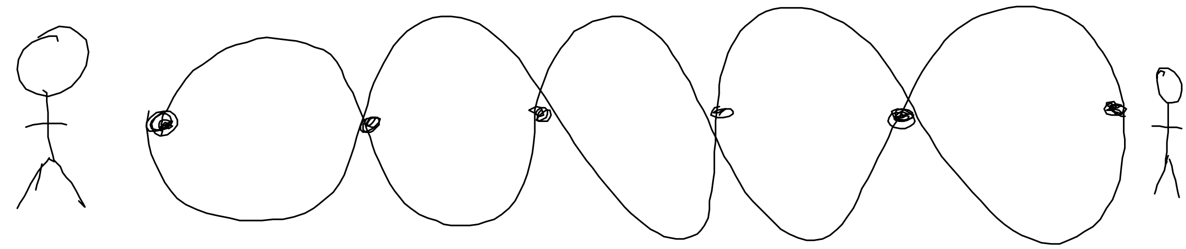
- **Beats** are the periodic and repeating fluctuations heard in the intensity of a sound when two sound waves of very similar frequencies interfere with one another.



- beat frequency
  - rate at which the volume is heard to be oscillating from high to low volume
  - For example, if two complete cycles of high and low volumes are heard every second, the beat frequency is 2 Hz.
  - The beat frequency is always equal to the difference in frequency of the two notes that interfere to produce the beats.
- Longer Beats video: https://www.youtube.com/watch?v=8vUuGRaTQ2E
- Shorter Beats video:
- https://www.youtube.com/watch?v=dD9gtq08tss

consonance (pleasing sounds)
dissonance (unpleasant sounds)

(18) $L = 6.0\,m$



5^{th} harmonic

$v = \lambda f$ (need f)

$L = \frac{5}{2}\lambda$

$6 = \frac{5}{2}\lambda \quad \lambda = 2.4\,m$

$f = \frac{85}{min} \times \frac{1\,min}{60\,s} = \frac{1.42}{s} = 1.42\,Hz$

$v = \lambda f = (2.4\,m)(1.42\,Hz)$

$v = 3.4\,m/s$

$v = \lambda f$

- v → speed
- λ → wavelength
- f → frequency (Hz) → $\frac{\text{vibrations}}{\text{second}}$

Speed
m/s

Wavelength
metres

y vibrations/second

~ in air → speed of sound

~ in rope → speed of rope